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PHYSICAL GEOGRAPHY.—*Peat profiles of the Everglades in Florida: the stratigraphic features of the "Upper" Everglades and correlation with environmental changes.*[1] ALFRED P. DACHNOWSKI-STOKES, U. S. Bureau of Chemistry and Soils.

INTRODUCTION

In the following an account is given of the structural features of the Upper Everglades secured through a method of field work described elsewhere (5). The profile studies were made in the hope of determining the origin and past history of this vast area of sedge peatland, probably one of the largest sub-tropical low moors in the world.

The material was for the greater part collected in the winter months of 1920, 1928, and 1929. The field work in 1920 was made possible by the coöperation and aid of G. V. Scott, engineer in charge of the Everglades State Drainage District, in whose company the more inaccessible parts of the Everglades were sounded. In 1928 and 1929 the studies in the field have been supported by coöperation from the Agricultural Experiment Station of the University of Florida. Their prosecution was greatly facilitated by R. V. Allison of the Everglades Experiment Station at Belle Glade. The horizontal and vertical control data and lines of elevation above sea level are due to assistance in 1929 from engineers of the State Drainage District. The writer wishes to convey his sense of deep obligation to Dr. Wilmon Newell, Dean and Director of the State Agricultural Experiment Stations, to Dr. R. V. Allison, and to Mr. G. V. Scott for the special facilities provided for studying in detail many parts of the Everglades.

[1] Received February 3, 1930.

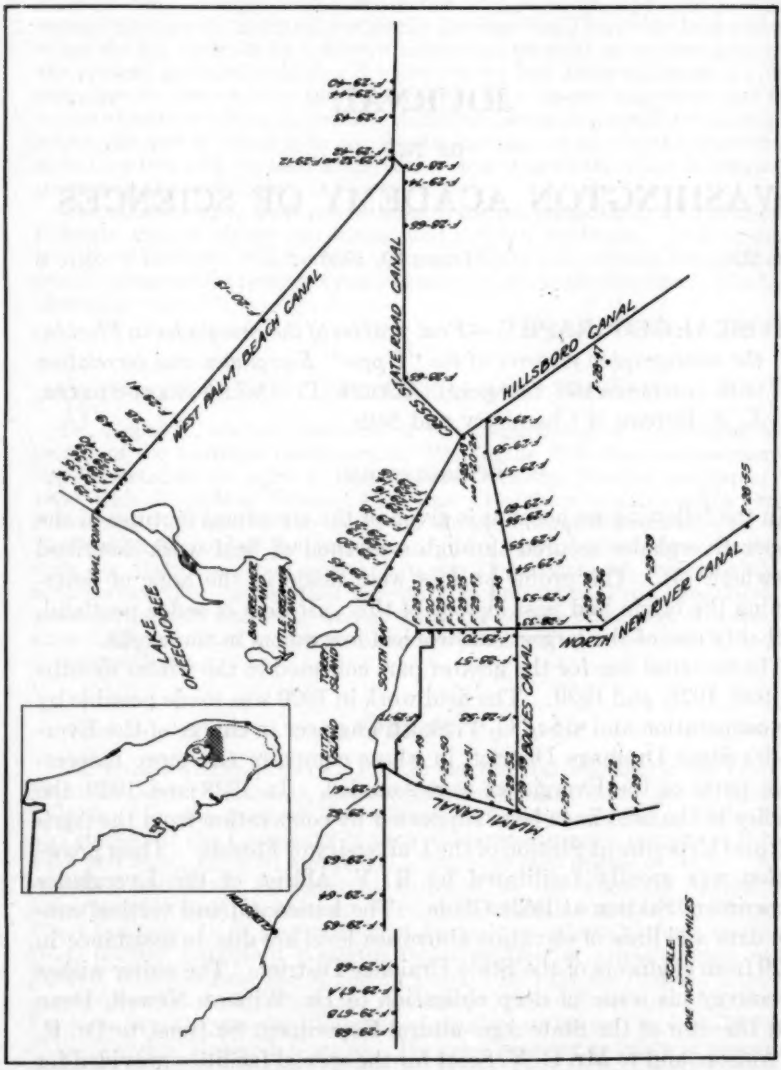

Fig. 1.—Map showing location and numbers of peat profile soundings in the Everglades of Florida covered by the reconnaissance survey of 1929. Prepared by the engineering division of the Everglades State Drainage District, West Palm Beach, Florida.

GENERAL CONSIDERATIONS AFFECTING THE STUDY OF EVERGLADES PEAT PROFILES

The present paper does not pretend to reconstruct conditions in all parts of this region but aims to present briefly the profile record of the Everglades south of Lake Okeechobee and a consideration of the consequences of changes in water level and shore lines.

The profiles used are representative of a much larger number obtained by the writer. The locations of the profiles along the several lines of traverse are indicated on the map Fig. 1 and the general relations of the peat layers to each other and to the configuration of the bedrock are shown in Figs. 2 to 7. The large number of soundings plotted to scale has made it possible to check the several layers of the

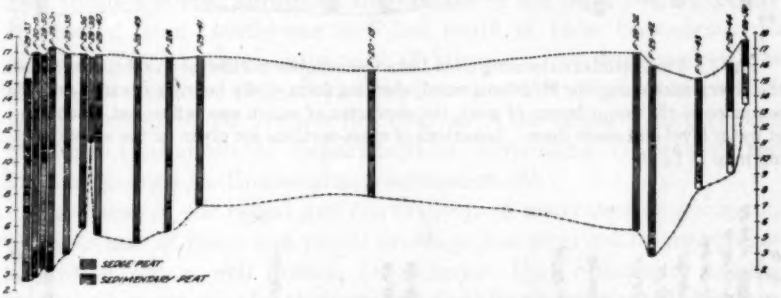

Fig. 2.—Peat profiles from Lake Okeechobee at Canal Point, Florida, northwest to southeast along the West Palm Beach canal, showing rock-bottom topography and diagrammatic details of the structural features of the Everglades. Surface variations are due to shrinkage, compression, and fires following drainage. Numbers at top of sections and distance apart between cross-sections correspond to locations shown on map of Fig. 1. Elevations are based on one common geodetic datum of sea level.

stratigraphic sections. The data from excavations made along the face of canals and from pits dug in differently situated parts of the same region show excellent correspondences wherever the exact location above sea level of the respective layers was determined.

In Fig. 2 are reproduced in graphic form the results of soundings made with an American peat-sampling instrument. The cross sections illustrate a transect profile running from Lake Okeechobee at Canal Point southeastward along the West Palm Beach Canal to the eastern border of the Everglades. The contour of the bedrock of limestone is well shown and it is evident, despite the decrease in number of soundings going eastward, that the structural features of the profiles show marked uniformity. The same conclusion applies to the profiles

Palm Beach, Florida.

in Figs. 3 to 5 which were taken parallel to the Hillsboro, North New River, and Miami canals. In the profile transect of Fig. 7 which combines the results of soundings along canals of two subdivisions of

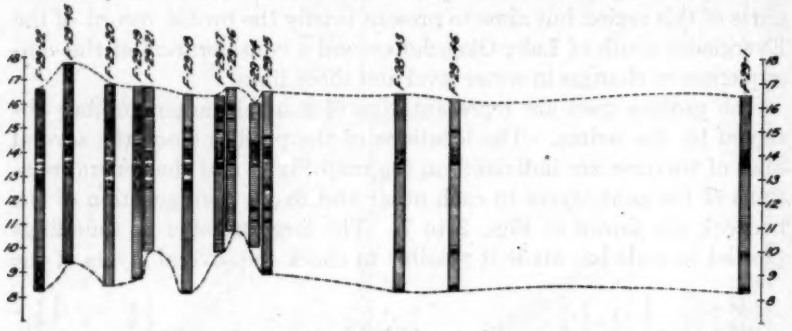

Fig. 3.—Peat profiles extending from Lake Okeechobee northwest to southeast across the Everglades along the Hillsboro canal, showing form of the bedrock contour and the sequence of the major layers of peat, the character of which was influenced by changes of water level and shore lines. Locations of cross-sections are given on the accompanying map in fig. 1.

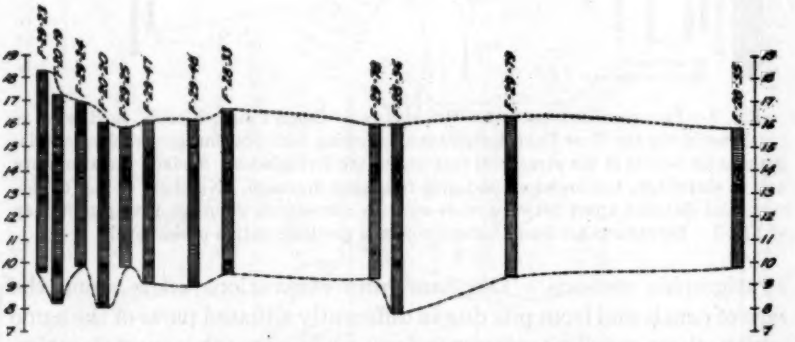

Fig. 4.—Cross-sections along the North New River canal showing rock-bottom configuration, contrasts in the sequence of peat layers, and transition of stratigraphic features from Lake Okeechobee to Okeelanta and southward. Changes in water level and shore line are recorded by the character and succession of the major layers of peat. Number and location of each profile are shown on the map of fig. 1.

the Drainage District, the sudden apparent greater simplicity of profiles near the western as well as the eastern border (Fig. 2), where they merge into higher land commonly called the rim of the Everglades, is particularly noticeable.

Before drainage began the Everglades presented the appearance of a broad, level, grass-covered prairie, sloping gently toward the south at the rate of about three inches per mile. Extensive drainage operations have caused, however, compression of the canalward edge of the Everglades, often changing the characteristic position above sea level of the main layers of peat. The profile sections along the south shore of Lake Okeechobee and the canals of the Everglades, it will be noted, show the discrepancy due to settling from drainage and the differences in the surface contour which now conform partly with the bedrock topography, but are chiefly the result of fires and oxidation.

A striking and important feature of the Everglades is the raised form of the southern shore of Lake Okeechobee. In cross section the surface forms a curve, abrupt at the margin of the lake, sloping gently southward from twenty-one feet just south of Lake Okeechobee to about six feet above sea level west of Miami. This slope is shown in the profile diagrams (Figs. 2 to 7) and on the charts of the main canals which accompany the reports to Congress of the Office of Experiment Stations, United States Department of Agriculture (7) and of the Florida Everglades Engineering Commission (8).

The cause of the raised and convex form of many peat deposits and the presence of lakes and ponds on them has received frequent consideration. It is well known, for example, that Sphagnum mosses and marsh vegetation by their growth and the clogging up of drainage channels, raise the water level to considerable heights. The highmoors in Maine and in Europe, with ponds of standing water on the elevated surface, the presence of Lake Drummond within the Dismal Swamp near Norfolk, Va., and the ponded water of the present Lake Okeechobee are examples of such results. The interlacing net-work of roots and rhizomes from sedges and herbaceous perennials, constantly compacting under the increasing weight of accumulating plant remains, greatly hinders water from flowing out of the matted and felty-fibrous mass of peat to a lower level. Periodically changing in height under wet years and shrinking in drier times, the formation of areas of raised peat is generally attained best in humid climatic belts where the supply of water is abundant for the growth of native vegetation and where layers of peat, more or less impervious, impound drainage water at varying elevations. Lake Okeechobee represents the height at which a layer of dense, finely divided sedimentary peat, superimposed upon a basal layer of fibrous sedge peat can pond a large body of water at the margin in a hydrostatic condition. Prior to drainage operations

the lake did not rise to a higher stage than 22½ feet because the lake overflowed its banks along the entire south shore. During prolonged periods of rainfall a sheet of water covered large portions of the Everglades, retarded in its movement by the dense growth of the saw-grass and the buoyancy of the water-soaked fibrous peat.

For the attempt to reconstruct from the profile soundings some of the important physical conditions which prevailed in the past of the Everglades, the clue is taken in the succession of peat layers from the base of the bedrock upward. Peat-profile studies carried out with uniform methods, as described by Lundquist (12), correlate and har-

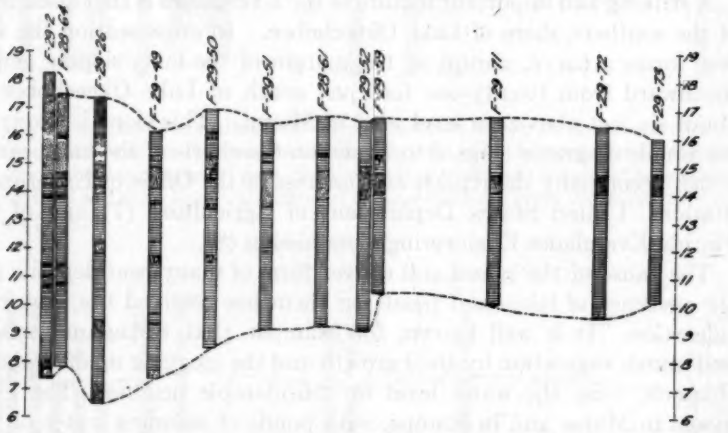

Fig. 5.—Peat-profile traverse along the Miami canal, showing bedrock topography and cross-sections through the Everglades from north to south. The locations of the peat profiles are given on the map in fig. 1.

monize results and increase greatly the knowledge of past vegetations and the growth of plants. Series of peat profiles furnish not only the best material for historical studies regarding the character of the ancient vegetation, but they serve also as a record for the study of changes in environment. The general profile studies of the Florida Everglades furnish independent evidence and confirm the same conclusion. The position of peat layers above sea level at one locality with the position of similar layers at other localities identifies them as the record of the same period and conditions. The profiles record without doubt geologically recent changes in the water level and shore line of Lake Okeechobee.

LOCATION AND DESCRIPTION OF TYPE PEAT PROFILES

It may at first thought appear undesirable to use the detailed field records available for representative type profiles. But in order that the reader may judge conclusions with a fuller knowledge of the nature of the evidence available, it is believed that the original data for at least three peat-profile soundings may be pertinent in connection with later discussions of the origin and history of the Florida Everglades.

A description is given, in the following, of the profile sections which were measured on the banks of the West Palm Beach Canal. The sequence of peat layers obtained along this canal affords as good a basis as any from the other main diagonal canals, of inferring the environmental conditions which prevailed during the deposition of the chief layers of peat.

1. Lake Okeechobee Area

F-29-33. At the lake shore, 300 feet north of the U. S. Sugar Cane Breeding Station at Canal Point, northeast of the entrance to West Palm Beach Canal. Elevation of ground surface and water in the lake 15.5 feet and of bedrock 2.9 feet above sea level.

1. Black, compact, sticky, wet sedimentary peat, sandy at the surface with thin band of shells (species of *Planorbis* and *Physa*) at 16 to 17 inches below the surface. Based upon sea level measurements the marly material appears to be identical with that in a profile sounding 2,000 feet from Lake Okeechobee, on the south side of the ridge of dune-like sand which borders the shore of the lake. The sedimentary material is finely divided, dense, and more or less colloidal between the 2 and 3-foot level below the surface; at the 4-foot level are 6 to 8 inches of brown, fibrous, laminated, compressed sedge peat mottled with yellowish, flattened rootstocks from *Pontederia* and other herbaceous plants. Below this continues to the 5½-foot level a very dark brown to black sticky sedimentary peat.

2. Dark brown partly sedimentary and fibrous sedge peat, stringy from coarse rhizomes of *Cladium* and *Scirpus;* the material is reddish-brown, moist, fibrous-matted, and poorly decomposed sedge peat at the 7-foot level below the surface; it gives off a fairly strong odor of hydrogen sulphide. Marsh gas is escaping in slight amounts.

Between the levels of 7 and 9 feet from the surface the layer shows two to three alternating bands of dark brown sedimentary-fibrous sedge peat followed by reddish-brown poorly decomposed saw-grass peat. The limits of the bands are indistinct. Below the 9-foot level the sedge peat is predominantly reddish to yellow-brown, coarse, partly decomposed, matted to felty fibered and chiefly the network of roots of *Cladium* with culms of grass-like plants. The material is porous, spongy, and wet, and has a distinct odor of hydrogen sulphide.

At the 12-foot level appears a grayish oozy shell and *Chara* marl with the remains of roots and rhizomes from sedges. The marl varies in purity and thickness; it becomes cream-colored toward the bottom and rests on bedrock of white limestone.

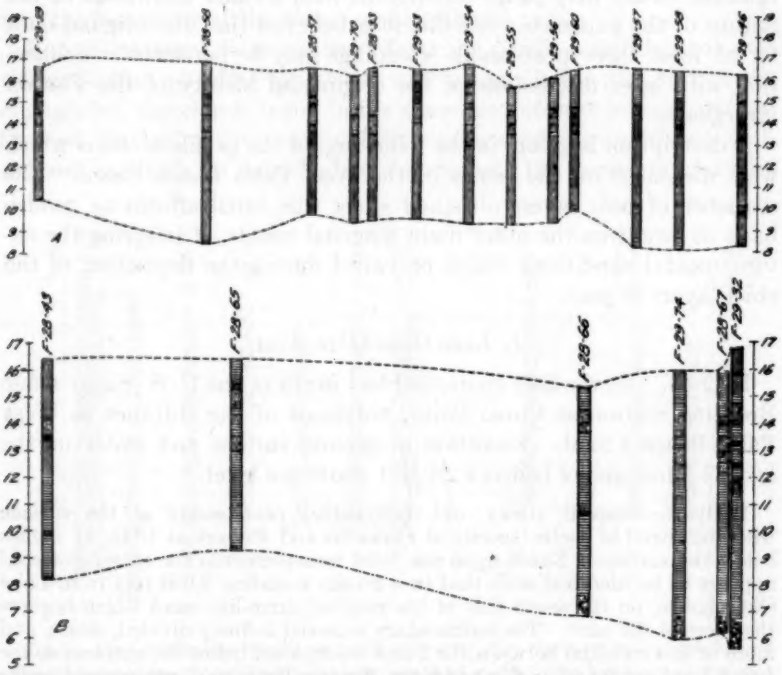

Fig. 6.—Peat profiles in a traverse from west to east across the Everglades along the Bolles canal, showing the development of peat layers by marsh and aquatic groups of vegetation in response to changes of water level and shore lines.

A. Miami canal to Hillsboro canal.

B. Cross-State Road canal from Hillsboro canal to West Palm Beach canal.

Location of sections shown on map of fig. 1.

Essentially the same structural features were observed more typically in the peat sections on Torry Island in Lake Okeechobee, and in belts of different width bordering the lake shore at the Hillsboro, North New River, and Miami canals. The Okeechobee peat profiles are a typically two-layered series.

2. Upper Everglades Area

F-20-13. Opposite Lateral A, about 10 miles southeast of Lake Okeechobee and 50 feet west of West Palm Beach Canal on Conners highway. The section was first measured in 1920 when saw-grass vegetation and a high water table extended on all sides to the horizon line, relieved in a few places by clumps of low shrubs. The surface elevation at present is 15.10 feet, lower by 11 to 13 inches than formerly, due partly to fires and drainage. The bedrock stands at 7.3 feet and the water level in the canal is at 12.85 feet above sea level. The record below refers to the field notes of 1920.

1. Dark brown, wet, fibrous matted sedge peat, darkened by fires in the upper two inches, contains charred debris; scattered over the surface are thin lenses of small pond snails, plants of *Chara* sp., and small calcareous pellets of blue-green algae. This is followed by brown fibrous crumbly saw-grass peat, mottled with dark-brown, finely-divided debris; between the 12 and 18-inch level below the surface the sedge peat is coarser, reddish to yellow-brown and more firmly matted.
2. Blackish-brown sedimentary-fibrous peat approximately 8 to 10 inches in thickness; dense, sticky, plastic and rather impermeable at the lower level, the fibrous components are more abundant at the limits of the layer.
3. Reddish-brown, felty-fibrous, matted sedge peat from about 38 to 50 inches below the surface; the material is firm, tough-fibered and has a moderately strong odor of hydrogen sulphide; at depths of 50 to 74 inches occur alternating bands of dark-colored sedimentary and fibrous mixtures followed by reddish to yellowish-brown, poorly decomposed, felty-fibrous sedge peat; the limits of the bands are indistinct and the upper one appears to separate into two thinner bands. This is followed by reddish to yellowish-brown fibrous moist saw-grass peat, spongy, poorly decomposed, odorous, in a compressed condition at the lower level; contains spicules of fresh-water sponges at the bottom and rootstocks of water-arum with needle-like raphides. Odor of hydrogen sulphide fairly strong below. At depth of 96 to 102 inches is found a grayish-white soft marl with rootlets of sedges, oozelike on bedrock.

The individual measurements, which were made in dugout pits and excavations along the main canals in addition to the soundings with the peat sampling device, show excellent agreement with each other. The Everglades series of profiles is distributed over a very large portion of the interior. The peat profiles are uniformly three-layered.

3. Marginal Area of the Upper Everglades

F-29-43. Approximately 22 miles southeast of Lake Okeechobee, along West Palm Beach canal, and 150 feet from north side of highway. Large areas in this neighborhood have been burned over severely. It was formerly a border zone of shrubs such as wax myrtle, swamp bay, magnolia, willow and a *Baccharis*. Wooded islands or hammocks

of cypress (*Taxodium distichum*) occur from 2 to 4 miles farther east, invading the saw-grass. Surface elevation 15.1 feet, bedrock elevation 8.1 feet above sea level. Water level in canal at 11.49 feet.

1. Thin horizon of charred granular debris, chiefly from saw-grass peat, with yellow ash. Below it the plant remains consist of poorly decomposed brown, coarse-fibered roots and rhizomes from saw-grass and unidentifiable grasses and sedges. The material is very compact and firm near the surface but porous, moist, and felty at the lower level. Toward the bottom, about 36 to 60 inches below the surface, the layer shows a scattered admixture of herbaceous plant remains and includes lenses of sand probably of windblown origin. Elongated veins contain black finely divided material, and rest on

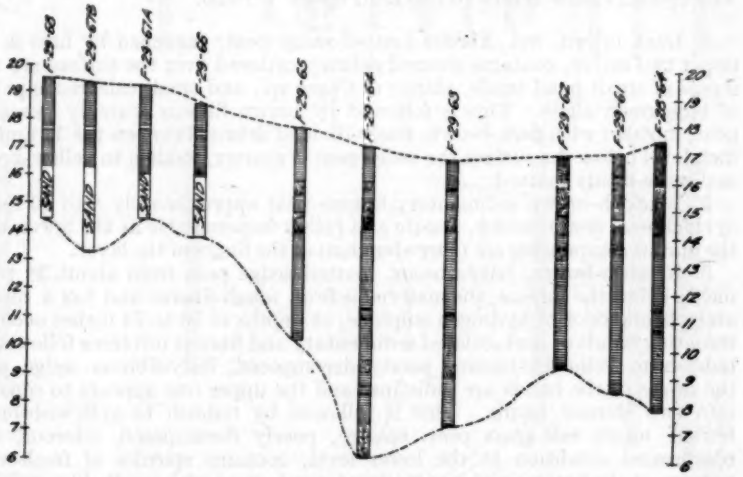

Fig. 7.—Peat profiles of belts extending from sand bars, bordering the margins of the Everglades, toward the Miami canal, and showing variations in the sequence of peat layers near the eastern and western end of the drainage canals. Locations of profile sections are indicated on the map of fig. 1.

gray sand with rootlets of sedges at the contact; the underlying sand rests on bedrock of porous limestone.

The peat profiles of the Ridge series are typically one-layered units, relatively young, and not of very extensive occurrence. They are abundantly distributed over the eastern and western border of the Everglades and occur also in some of the sedge marshes of the east and west coast.

PHYSICAL CONDITIONS DURING THE FORMATION OF THE EVERGLADES

From the sequence of the peat layers in the profile sections described above it is not difficult to reconstruct the history of the "Upper" Everglades.

It may be inferred from the conditions summarized by Sanford (13) that the lowest coastal plain, the Pensacola terrace within which the Everglades are included, was formed during comparatively recent Pleistocene time. Following an uplift of the mainland, the Kissimmee River and its tributaries flowed southeastward through a broad flat valley cut mainly in the bedrock of limestone. It was during this period of erosion that the major features of the present rock-floor configuration with its irregular and jagged ridges, deep fissures, hollows, and scattered Keys were produced. Hills of sand were deposited, probably by a southward drift along the outcrop of bedrock around the border of the Everglades, and widespread beach sands, driven inland through the central part of the plain, assumed their present form. Concerning the geographic extent of the emergence, which may have been intermittent, there is still some doubt. The details that connect the geographic character of the country with its Pleistocene geology and with other natural features, are emphasized in the publications of the Federal Government (2, 7, 8), and the reports of the Florida State Geological Survey (10), the State Drainage District (6) and the State Agricultural Experiment Station (1).

The events which are primarily responsible for the history of the "Upper" Everglades may be set forth as follows:

Subsequent to the period of erosion a change came in the relative level of land and water. The change brought the surface of the bedrock of the Everglades to or near its present level, and, where formerly there was an effective drainage, now shallow waters occupied small blocked depressions, hollows, and potholes in the rock.

Aquatic vegetation began to invade the ponds and deeper axes of the drainage-valley bottoms where the bedrock sloped off more steeply. Reference to Forsaith's (9) microscopic and comparative studies of the plant remains in the lakes and ponds of Florida shows the character of most of this type of vegetation. Submerged aquatics were represented by cosmopolitan but essentially northern species comprising *Vallisneria*, *Naias*, *Potamogeton*, *Utricularia* and others; the floating aquatics included *Nymphaea*, and possibly *Pistia* and *Piaropus*, with detached masses of *Scirpus* scattered along the shores. Large mats of *Chara* and blue-green algae together with numerous water snails and bivalves which fed on submerged roots and stems, yielded gray limey oozes and shell marl.

Bordering them, a fairly uniform saw-grass marsh, very much as today, with grasses, sedges, ferns, and herbaceous semi-aquatics having

fleshy rootstocks, slowly encroached upon the exposed rocky floor. Many northern species, both of plants and animals, had extended their range southward to this region or were represented in the sedge marsh by varieties which take the place of northern types. They spread over sands and muddy oozes, and covered wide expanses of bedrock including large areas now occupied by the present Lake Okeechobee.

Fig. 8.—Upper portion of a profile section in a lateral canal showing on the face of the bank a surface horizon of saw-grass muck (the residue derived from decomposition of saw-grass peat) and a dark band of sedimentary-fibrous sedge peat between layers of brown fibrous saw-grass peat. Photographed by R. V. Allison, March 29, 1929.

Brown fibrous sedge peat, spongy and watersoaked, formed a continuous layer over the limestone. The fact that no true sedimentary layer of peat is discovered at the bottom of most of the soundings is sufficient proof that at no time during this early period of peat formation did the general water level occupy a high elevation or was it rising rapidly enough to destroy the growth of the saw-grass and initiate the accumulation of a different type of peat on the rock floor of the Everglades.

The effect of sand blown from dunes upon the marsh is shown in the extremely sandy peat material encountered in those soundings which are nearest the peat-covered dunes and bars.

That the rock floor of this region was not occupied at first by an inland sea or body of open water as Matson (13) and Harshberger (11) contend, is evidenced by F-29-33 which recapitulates the general history of Ritta and Torry islands in that lake (3). The profiles in Figs. 2 to 7 also present features incompatible with the interpretation of them as products of a basin-like depression or of the filling up of an inland lake; they are too strongly suggestive of their autochthonous origin. The east-west profiles along the Bolles Canal and its extension eastward to the West Palm Beach Canal (Fig. 6A and 6B) serve as a useful check since in places they cross certain of the significant profiles of the main diagonal canals and confirm the developmental features shown on the northwest-southeast series of transects. The origin of Lake Okeechobee did not take place until a later period. It came into existence probably through springs or the effects of subterranean drainage and solution. The dense growth of sedges and their matted network of roots and rhizomes held back the water of heavy rainfalls and at first a chain of narrow lakes was probably ponded off between Kreamer and Ritta islands (Fig. 1). The exact position of the original series of lakes between the islands is not yet known. On the north side of Lake Okeechobee floodwaters from the mouth of the Kissimmee River carried in suspension mineral material and deposited silt and sand over the bedrock bottom. This deposition may have proceeded for a considerable length of time, but the mineral sediments do not appear to be very thick. In contrast to this the evidence collected from profile soundings on the south side of the lake and in the Everglades proper indicates the presence of a basal layer of fibrous sedge peat. Minor overflows occurred from time to time, causing the water to encroach over the saw-grass marsh of that period and to persist for moderately long intervals. The admixtures of sedimentary peat, aquatic in origin, found embedded in the brown fibrous sedge peat at various levels, obviously are equivalent to the amount and length of overflow submergence. Especially at depths represented by tide elevations of 7 and 11 feet above sea level (Fig. 2), quantities of sedimentary material embedded in poorly decomposed sedge peat, differing in morphological characteristics from plant remains above and below these levels, must be credited to the agency of fluctuating water levels. The formation and deposition of both organic and silty

material at the higher levels are proof of the existence of initial shore lines of a temporary lake, and an indication that a change to higher water levels had affected the region.

Subsequent to the minor overflows, and as the water level fell, saw-grass vegetation again advanced northward beyond the present shore line of Lake Okeechobee. The plants continued to build up an accumulation of sedge peat, holding water to surface level by capillarity. In addition to the saw grass, *Cladium effusum* (*Mariscus jamaicensis*), the most common component of the fibrous peat layer, the plant remains denote the presence of species of *Rhynchospora*, *Panicum*, *Andropogon*, ferns such as *Osmunda regalis*, *Acrosticum* sp., and herbaceous plants as elements of the ancient marsh community. The only species found as seemingly pure bands of peat are *Peltandra* with *Sagittaria* and *Pontederia* which occupied ancient lagoons and sloughs. The water appears to have oozed slowly southward, on the east side toward the southeast and on the west side toward the southwest.

The most extensive submergence by overflow, greatest in amount of sedimentary peat deposition and bringing the layer farthest out over the interior of the Everglades region, occurred later. All the measurements strongly affirm the interpretation that a rapid change due to the release of large masses of water marks the period when the accumulation of fibrous sedge peat had reached elevations between 12 and 13 feet above sea level. In its inundated condition the region was covered with water, probably to a foot or more in depth, fluctuating in level from time to time but enduring for a relatively long period. Both the upper and lower edges of the sedimentary peat of that time are rather sharply demarked, and the continuity of the layer is traceable the entire distance from Kreamer Island in Lake Okeechobee to a line north of the Tamiami Trail, between Miami and the west coast, where the layer has the form of thin projecting lobes. A preliminary study of the plant remains seems to indicate a general and great change in surface vegetation.

The whole aspect of the peat profiles is such as to justify the assumption of fluctuating and long-standing high water conditions. But the factors are yet to be determined that caused the water level to rise and stand. The problem is exceedingly complex since some of the factors such as bedrock topography, rainfall, evaporation, run-off, and percolation in the Everglades are not well understood. The underground water supply through porous or probably cavernous limestone is also an unknown and vitally important factor which will require study and observation.

When the waters again fell and withdrew to a lower level, the present Lake Okeechobee came into existence. Lowering of the water table exposed a narrow zone of sedimentary mud flats on the south shore of the lake, and was accompanied by the rapid invasion of deciduous broad-leaved trees and shrubs. A dense growth of custard apple trees (*Anona glabra*) became dominant and formed a forest in which other tree-like vegetation was scant. Many of the older trees had enlarged bases induced by the influence of submergence in water. The location and width of the "custard-apple belt," previous to its destruction coincident with drainage and cultural operations, are shown on the phytogeographic map published by Harshberger (11).

A comparison of the peat profiles in the "custard-apple belt" between the shore of the Lake and the interior of the Everglades suggests more differences than correspondences in the upper and recent layer of peat. The disagreement, however, is essentially due to fluctuation in water level. Woody peat is lacking entirely. Readvances of the shore line are marked by readvances in aquatic vegetation and corresponding deposition of sedimentary peat; periods, short in duration, of lower water supply are correlated by the development of saw-grass vegetation and herbaceous plants which were favored and pushed forward over the exposed mudflats. Some of the bands of shell marl below laminated, platy, yellowish-brown, fibrous peat derived from *Pontederia* and semiaquatic members of the *Naiadales* and *Arales* surely record a wide re-entrance of saw-grass vegetation over sedimentary peat, and a corresponding drainage of the lake and of the Everglades. The extent and the number of oscillations in water level seem to have been small, for the bands are disturbed and alternate irregularly at several localities. Although thin layers of fibrous and herbaceous sedge peat extend beyond the present lake margin, they have only moderate thickness and indicate effects of an unstable shore line. This supposition is strongly supported also by the fact that in the interior of the Everglades and in the bays of Lake Okeechobee the corresponding layers of sedge peat record more uniform conditions. As already noted in another connection (4) they suggest that during the last few thousand years there has been no major differential submergence and no appreciable change in the relative positions of water level. The evidence indicates that custard-apple hammocks established themselves only recently upon the mud flats along Lake Okeechobee, and the record of the peat profiles leads toward the conclusion of an essentially stable coastal plain in historic time.

A ridge of fine silicious sand occupies the northeast and east shores of Lake Okeechobee. The sand ridge at Canal Point is about six feet high, varies in width from about 25 to 200 feet and rests on sedimentary peat along the entire southeastern shore of the lake. Prior to drainage operations it was clothed with bald cypress (*Taxodium distichum*), maple (*Acer carolinianum*), ash (*Fraxinus caroliniana*), holly (*Ilex cassine*), strangling fig (*Ficus aurea*), palmetto (*Sabal palmetto*), many shrubs, and herbaceous undergrowth; the stand was almost impenetrable in many places. These low dune-like ridges and mounds of sand are not directly related to the present shore line, although they occur near the shore of Lake Okeechobee and are not found inland on the saw-grass peat of the Everglades. From their position they may be in part the work of winds and in part due to wave action, particularly southward-setting currents; they were probably formed more or less recently, but at a time when water level conditions favored sand drift.

The present vegetation of the Everglades has been described in great detail by Harshberger (11). Consultation of the phytogeographic map which accompanies his monograph will show the limits of the saw-grass vegetation and diverse plant communities, but not of the actual accumulation of saw-grass peat. Harper (10) has listed the constituent plants of the principal types of vegetation and has given many sources of information in his bibliography. To complete the picture it is necessary to keep in mind that broad-leaved shrubs and trees belonging to types essentially southern in range and characteristic of the belt of cypress-tupelo-red gum swamps have been invading the Everglades only recently. As yet layers of woody peat derived from them are lacking. In the interior of the Everglades are scattered hammocks or islands of hardwood trees and shrubs with vines, ferns, and epiphytes. Where fires do not suppress it, this group of vegetation is displacing the saw-grass more or less rapidly. In a not-distant future hammock vegetation will be typical where the saw-grass is still in evidence.

CONCLUSIONS AND NEW PROBLEMS

In the present paper the primary object has been to treat in a preliminary fashion the general origin and nature of the upper portion of that large stretch of sedge moor, the Everglades of Florida, one of the largest subtropical peat areas in the world, extending from Lake Okeechobee to the Gulf of Mexico.

Three distinct but genetically related series of peat profiles are pointed out. (1) the area of profiles in and bordering Lake Okeechobee; (2) the area of profiles in the main interior portion of the Everglades; (3) the area of peat profiles bordering the highland. The general relations of these three series of profiles to each other are shown diagrammatically in Figs. 2 to 7. The morphological features and botanical composition which characterize representative soundings of each of these series of profiles have been described and the effects of oscillations of water level upon the stratigraphic origin and form of the profiles were considered. It is concluded that the salient features of the Everglades do not find an explanation in the geologic structure, or in the configuration of the bedrock as an inland lake; the peat profiles show a remarkable dependence upon inundations and oscillations of water level and corresponding changes in shore line during a time relatively recent. The Upper Everglades of Florida present the aspects of a eutrophic sedge moor characterized by series of one-, two-, and three-layered telmatogenic profiles.

A number of special problems possess more than ordinary interest. It is in the wide bearing not only on practical agriculture but also on fields of science, particularly Pleistocene geology, geography, botany, climatology and even archaeology that their scientific value and importance are to be found.

If a sufficient number of profile measurements can be secured together with their elevations above sea level, the successive positions of ancient Lake Okeechobee, the several stages and forms of the receding and advancing shore line can be mapped. It is hoped that such a valuable list of accurate measurements as that obtained through the coöperation with the Everglades State Drainage office will be made for a large number of points along lines of traverse in an east-west and north-south direction. They have a high scientific and practical value. There is a scarcity of trustworthy data for solving certain difficult problems in regional peat investigations, or on which to base reliable estimates of the rate and amount of shrinkage and decomposition of peat deposits under different climatic conditions and agricultural practices.

A closer treatment requires also biochemical analyses of the profile series, including the mechanical and chemical character of both the shore peat (littoral *gyttja*) and lake peat (limnic *gyttja*) as geographical types of sedimentary peat. Of considerable interest should be detailed quantitative and stratigraphic studies of pollen and other plant remains in the succession of peat layers.

It would be pertinent also to inquire into the causes of the inundations to which the region has been subject and which determined the primary characteristics of the Everglades peat soils. Determination of the extent, number, and duration of the overflows and changes in water level, the amount of fall and rise recorded by the peat profiles, should be of great interest in problems connected with the control of intermittent, impounded surface waters. The factors that caused longstanding high-water-level conditions and changes in the shore of Lake Okeechobee are yet to be determined. The theory of relatively recent oscillations of the coast, involving both emergence and subsidence of the Floridian mainland, is apparently disproved by the character of the Everglades peat layers and the absence of tidal-marsh peat.

An estimate of the length of time required for the formation of this interesting peat region with its flooded and ponded lake and shifting, complicated shore lines should be another aim in studies like this, especially if correlated with contemporaneous periods in the ice retreat in North America. Correlation tables already published (3) are only a beginning of the task of constructing a continuous record. The complexity and difficulty of the whole problem of possible changes of level requires contributions from different aspects, and the light of fuller knowledge than now at our command. Particular attention should be given to comparisons with northern coastal regions serving to clarify the relationship between stratigraphic features and environmental changes.

Studies to correlate the effects of drainage and of special chemical salts, applied to promote the growth of crops, are under way on fields representing each profile series.

REFERENCES

(1) ALLISON, R. V., BRYAN, O. C., and HUNTER, J. H. *The stimulation of plant response on the raw peat soils of the Florida Everglades through the use of copper sulphate and other chemicals.* Univ. Florida Agric. Exp. Sta. Bull. 190. 1927.

(2) BALDWIN, M. and HAWKER, H. W. *Soil Survey of the Fort Lauderdale area, Florida.* Field Operations, U. S. Bureau of Soils, 1919.

(3) DACHNOWSKI, A. P. *The correlation of time units and climatic changes in peat deposits of the United States and Europe.* Proc. Nat. Acad. Sci. **8**: 225–231. 1922.

(4) DACHNOWSKI-STOKES, A. P., and ALLISON, R. V. *A preliminary note on blue-green algal marl in southern Florida in relation to the problem of coastal subsidence.* This JOURNAL **18**: 476–480. 1928.

(5) DACHNOWSKI-STOKES, A. P. *The botanical composition and morphological features of "highmoor" peat profiles in Maine.* Soil Sci. **27**: 379–388. 1929.

(6) ELLIOT, F. C. Bienn. Rept. Everglades Drainage District, Tallahassee, Florida. 1925–1926.

(7) *Everglades of Florida.* U. S. Senate Doc. 89, 62nd Congress, 1st Session, Washington, D. C. 1911.
(8) *Florida Everglades.* U. S. Senate Doc. 379, 63d Congress, 2nd Session, Washington, D. C. 1914.
(9) FORSAITH, C. C. *Report on some allocthonous peat deposite of Florida.* Bot. Gaz. **62**: 32–52, 1916, **63**: 190–208. 1917.
(10) HARPER, R. M. *Natural resources of Southern Florida.* Eighteenth Ann. Rep. Fla. State Geol. Survey, 27–206. 1927.
(11) HARSHBERGER, J. W. *The vegetation of South Florida, south of 27°30′ north, exclusive of the Florida Keys.* Trans. Wagner Free Inst. Sci. **7**: 49–189. 1914.
(12) LUNDQUIST, G. *Methoden zur Untersuchung der Entwicklungsgeschichte der Seen.* Abderhalden's Handbuch der biologischen Arbeitsmethoden. Abt. 9, T. 2, (fig. 173), 427–462. 1925.
(13) MATSON, G. C., and SANFORD, S., *Geology and ground waters of Florida.* U. S. Geol. Survey, Water Supply Paper 319. 1913.

ZOOLOGY.—*Descriptions of two new amphipod crustaceans (Talitridae) from the United States.*[1]

CLARENCE R. SHOEMAKER, United States National Museum. (Communicated by MARY J. RATHBUN.)

While sorting a small collection of crustacea which was sent to the U. S. National Museum for identification by the U. S. Biological Survey in May, 1929, I noticed a species of *Orchestia* which was new to science. The specimens, one male and two females, were collected by Mr. F. M. Uhler, and in answer to my inquiry as to the exact locality, he says in his letter, "The specimens were taken on the north side of a small lake or pond located on the northwest side of Lake Monroe, and were found under a board on a rather sandy gently sloping margin, 2–4 yards from the water's edge. This spot apparently is in Volusia County, Florida, very close to the Seminole County line, and Sanford is the nearest town of any importance. This pond is located about 1–1½ miles from the bridge across the outlet of Lake Monroe, and is separated from the lake only by a strip of semi-dry marsh covered with vegetation. The water of the pond is supplied by a large sulphur spring, a sulphurous artesian well, and by high water from the main body of Lake Monroe. Lake Monroe is merely a broadened portion of the St. Johns River, and although the water apparently is fresh, it contains such marine vertebrates as the sting ray (*Dasyatis sabina*) which frequently enters fresh water."

I have designated this new species *Orchestia uhleri* in honor of its discoverer.

[1] Received February 7, 1930.

In 1905, Dr. James E. Benedict took some specimens of an *Orchestoidea* at Pacific Grove, California, which upon examination proved to be a new species. Mr. E. M. Chase collected further examples of this species on April 27, 1918 at Anaheim Bay, Seal Beach, California. Dr. Waldo L. Schmitt, during his investigations of spiny lobsters, procured additional material from kelp hold-fasts on the beach at La Jolla, California. Mr. Frank F. Gander has presented the National Museum with specimens which he took in 1927 at San Diego, California. Mr. Gander states that he took this species both in the littoral marine and at Balboa Park, which affords another example of a member of the family *Talitridae* extending from the coast to a considerable distance inland.

This species I have named *Orchestoidea benedicti* in honor of its discoverer.

Orchestia uhleri, n. sp.

Figures 1 and 2

Type-locality.—Near Lake Monroe, Volusia County, Florida, collected by F. M. Uhler, March 22, 1928; 1 male holotype (Cat. No. 62956, U. S. N. M.).

Male.—Eyes black, round, and of moderate size. Antenna 1 extending slightly beyond the fourth joint of antenna 2, flagellum composed of four joints and slightly longer than peduncle. Antenna 2 very nearly as long as the head and first four body segments, fourth joint of peduncle about three-fourths the length of fifth, flagellum composed of thirteen joints and as long as the fourth and fifth joints of peduncle combined. Mandible, cutting edge rather narrow and oblique and armed with two large and three smaller teeth, secondary plate well developed, two stout plumose spines and one or two smaller ones in spine-row, molar large and strong, bearing many transverse ridges on its slightly concave surface, and having at its base near the spine-row a dense brush of plumose setae. Maxilla 1, inner plate long and narrow and bearing on its distal end three plumose spines, outer plate bearing 9 serrate spine-teeth, palp very small with second joint about one-third the length of first. Maxilla 2, inner plate very nearly as long as outer and bearing on its obliquely truncated extremity many plumose spines and setae, outer plate evenly rounded distally and bearing many curved spines. Maxillipeds, inner plates reaching very nearly to the end of the first joint of palp, broadened distally, and bearing four short spine-teeth on their truncated ends, outer plates short and broad, reaching about one-third the distance along the second joint of palp, palp very short and broad, all the joints being wider than long. Lower-lip about normal. Gnathopod 1, side-plate very slightly concave in front and evenly rounded below, fourth joint with shallow lobe on lower margin, fifth with prominent lobe on lower margin, sixth joint about two-thirds the length of fifth, lower margin produced distally into a soft tumid lobe, palm short, transverse and armed with a row of long slender spines, seventh joint as long as palm, bearing about one-third the distance from the apex several slender setae, and armed on inner edge with three short blunt spines. Gnathopod 2 large and powerful, second joint four-fifths as

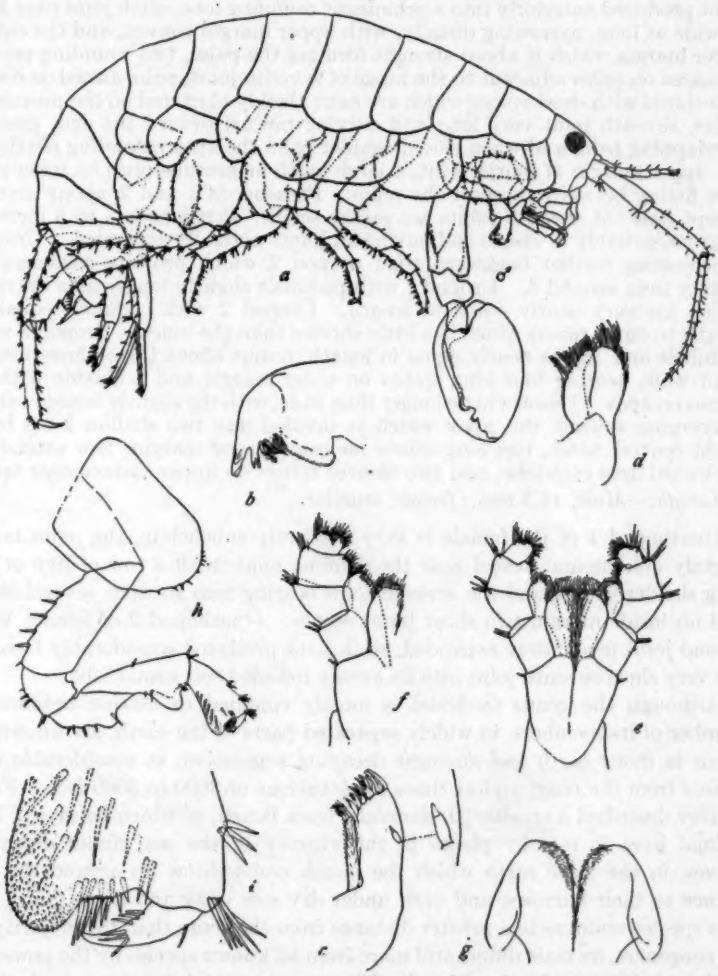

Fig. 1.—*Orchestia uhleri*, new species. Male, *a*, Entire animal. *b*, Right mandible. *c*, Maxilla 1. *d*, Maxilla 2. *e*, Maxillipeds. *f*, Maxilliped with palp flattened out to show entire width of joints. *g*, Lower lip. *h*, Gnathopod 1. *i*, End of sixth joint and seventh joint of gnathopod 2, enlarged.

long as sixth, produced at the lower anterior corner into a rounding lobe, third joint produced anteriorly into a prominent rounding lobe, sixth joint over half as wide as long, narrowing distally, with upper margin convex, and the entire lower margin which is about straight forming the palm, two rounding protuberances on palm adjacent to the hinge of seventh joint, palm armed on distal two-thirds with short spines which are more thickly clustered on the protuberances, seventh joint very long and curving inward toward the end, greatly overlapping palm and when closed against palm the apex extending nearly to the upper margin of fourth joint, a large tooth or protuberance on inner surface fitting between those of the palm. Peraeopods 1 and 2 about normal except that the seventh joints are rather small. Peraeopods 3 to 5 increasing consecutively in length and having all joints normally expanded. Uropod 1 projecting farther backward than uropod 2 which projects considerably farther than uropod 3. Uropod 1 with peduncle slightly longer than the rami which are very nearly equal in length. Uropod 2 with peduncle equal in length to outer ramus which is a little shorter than the inner. Uropod 3 with peduncle and ramus nearly equal in length, ramus about three times longer than wide, bearing four long spines on outer margin and a cluster of three spines on apex. Telson a little longer than wide, with the slightly concave sides converging toward the apex which is divided into two shallow lobes by a slight central notch, two long spines on each lateral margin, two extending backward from each lobe, and two shorter spines on upper surface near apex.

Length.—Male, 14.5 mm.; *female*, smaller.

Gnathopod 1 of the female is very distinctly subchelate, the palm being slightly oblique and armed near the defining angle with a row of five or six long slender spines, and the seventh joint bearing near its apex several setae and on inside margin two short blunt spines. Gnathopod 2 of female with second joint moderately expanded, sixth joint produced considerably beyond the very short seventh joint into an evenly rounded soft tumid lobe.

Although the genus *Orchestia* is mostly confined to marine beaches, a number of its members, in widely separated parts of the earth, are known to occur in moist earth and amongst decaying vegetation, at considerable distances from the coast and at times at elevations of 2000 to 3000 feet. Fritz Müller described a species (*O. darwinii*) from Brazil, of which he says, "The animal lives in marshy places in the vicinity of the sea, under decaying leaves, in the loose earth which the marsh crabs throw up around the entrance to their burrows, and even under dry cow dung and horse dung. If this species removes to a greater distance from the shore than the majority of its congeners, its male differs still more from all known species by the powerful chelae of the second pair of feet." The present record, I believe, is the first of the occurrence of this genus in North America at any locality removed from the coast, Lake Monroe being twenty miles from the nearest point on the east coast of Florida and about 120 miles from the sea by way of the St. Johns River.

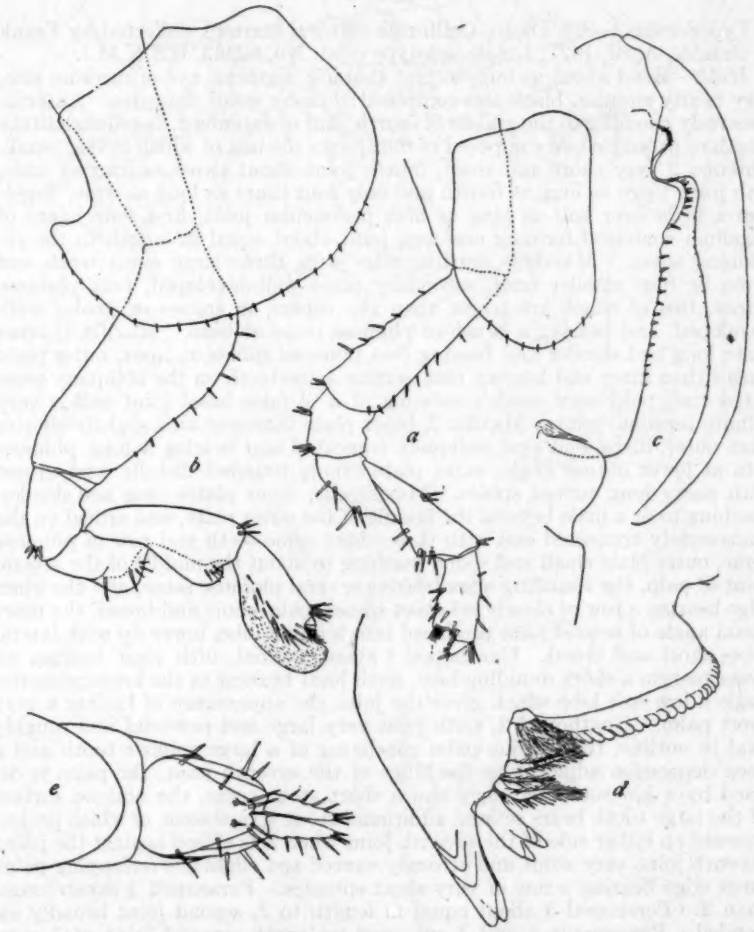

Fig. 2.—*Orchestia uhleri*, new species. *a*, Gnathopod 1, female. *b*, Gnathopod 2, female. *c*, Palm of sixth joint and seventh joint of gnathopod 2 of male, enlarged. *d*, Right mandible, enlarged. *e*, Telson and third uropods, male.

Orchestoidea benedicti, n. sp.

Figure 3

Type-locality.—San Diego, California (littoral marine), collected by Frank F. Gander, April, 1927; 1 male holotype (Cat. No. 62962, U.S.N.M.).

Male.—Head about as long as first thoracic segment, eye of medium size, very nearly circular, black and composed of many small elements. Antenna 1 scarcely reaching to the middle of fourth joint of antenna 2, flagellum half the length of peduncle and composed of four joints the last of which is very small. Antenna 2 very short and stout, fourth joint about twice as long as wide, fifth joint twice as long as fourth and only four times as long as wide, flagellum a little over half as long as fifth peduncular joint, first four joints of flagellum coalesced forming one long joint about equal in length to the remaining seven. Mandible, cutting edge with three large stout teeth and three or four smaller ones, secondary plate well-developed, four plumose spines, two of which are larger than the others, in spine-row, molar well-developed, and bearing a brush of plumose setae at base. Maxilla 1, inner plate long and slender and bearing two plumose spines on apex, outer plate longer than inner and bearing nine serrate spine-teeth on the obliquely truncated end, palp very small consisting of a slender basal joint and a very minute terminal joint. Maxilla 2, inner plate narrower and slightly shorter than outer, distal end very obliquely truncated and bearing a long plumose seta at lower obtuse angle, outer plate evenly rounded distally and armed with many long curved spines. Maxillipeds, inner plates long and slender, reaching to or a little beyond the middle of the outer plate, and armed on the transversely truncated end with three short spine-teeth and row of plumose setae, outer plate small and short, reaching to about the middle of the second joint of palp, the rounding apex bearing several plumose setae, and the inner edge bearing a row of closely set short spines, palm short and broad, the inner distal angle of second joint produced into a broad lobe, lower lip with lateral lobes short and broad. Gnathopod 1 about normal, fifth joint bearing on lower margin a short rounding lobe, sixth joint bearing at the lower posterior angle a low soft lobe which gives the joint the appearance of having a very short palm. Gnathopod 2, sixth joint very large and powerful and roughly oval in outline, the oblique palm consisting of a large spinose tooth and a deep depression adjacent to the hinge of the seventh joint, the palm is defined by a low rounding angle and a short stout spine, the oblique surface of the large tooth bears several additional stout spines some of which project forward on either side of the seventh joint when it is closed against the palm, seventh joint very stout and strongly curved and slightly overlapping palm, inner edge bearing a row of very short spinules. Peraeopod 1 much longer than 2. Peraeopod 3 about equal in length to 2, second joint broadly expanded. Peraeopods 4 and 5 subequal in length, second joint of 5 more widely expanded than that of 4. Abdominal segments 1–3 with lower posterior corners slightly produced into short acute points. Uropod 1 extending farther back than 2 which is farther produced than 3. Uropod 1, peduncle longer than the rami, the outer of which is the longer, peduncle and rami bearing spines on all their edges. Uropod 2, peduncle equal in length to outer ramus which is slightly shorter than inner, the edges of both peduncle and rami bearing spines, those of the peduncle being longer than the rest. Uropod 3, peduncle shorter than ramus. Telson about as wide as long, the sides converging to a narrowly rounded apex, several spines on the upper surface and a cluster on the rounding apex.

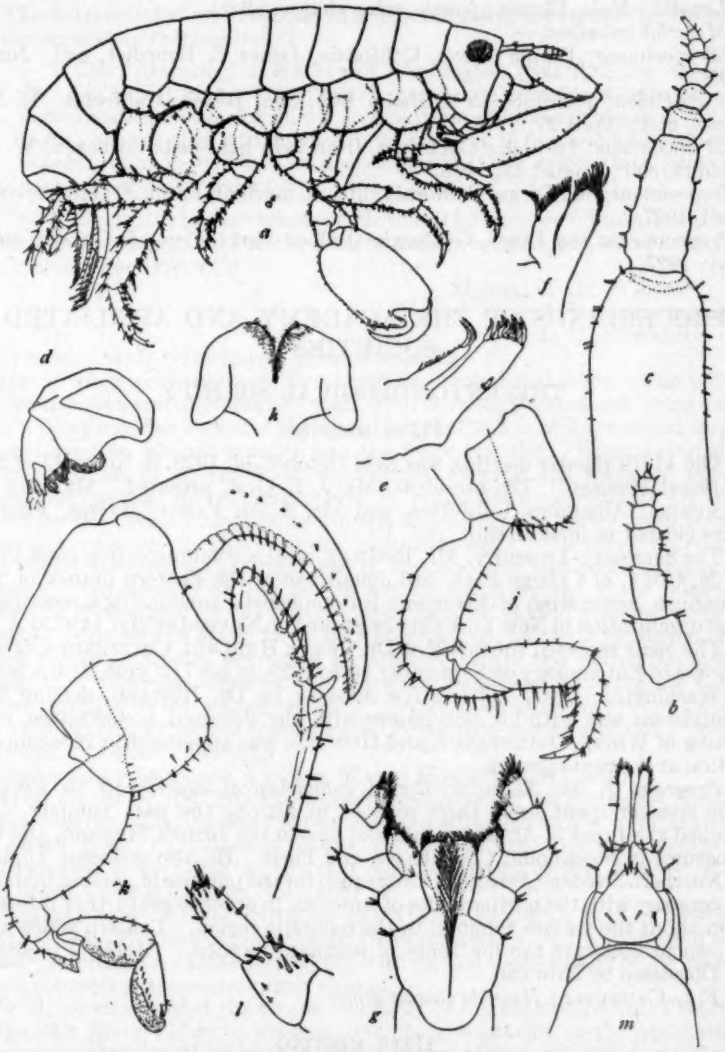

Fig. 3.—*Orchestoidea benedicti*, new species. Male, *a*, Entire animal. *b*, Antenna 1. *c*, End of fifth joint and flagellum of antenna 2. *d*, Right mandible. *e*, Maxilla 1. *f*, Maxilla 2. *g*, Maxillipeds. *h*, Lower lip. *i*, End of sixth joint and seventh joint of gnathopod 2, enlarged. *j*, Gnathopod 1, female. *k*, Gnathopod 2, female. *l*, Uropod 3. *n*, Telson and third uropods from above.

Length.—Male, 13 mm.; *female*, somewhat smaller.

Material examined.—

53 specimens; Pacific Grove, California, James E. Benedict, coll., June, 1905.

1 specimen; Entrance to Anaheim Bay, Seal Beach, California, E. M. Chase, coll., April 27, 1918.

27 specimens; La Jolla, California, from kelp hold-fasts on beach, W. L. Schmitt, coll., August 17, 1918.

9 specimens; San Diego, California (littoral marine), Frank F. Gander, coll., April, 1927.

5 specimens; San Diego, California (Balboa Park), Frank F. Gander, coll., May, 1927.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ENTOMOLOGICAL SOCIETY

413TH MEETING

The 413th regular meeting was held October 3d, 1929, in Room 43 of the National Museum. The president, Mr. J. E. Graf, presided. Mr. ROY E. CAMPBELL, Alhambra, California, and Mr. A. M. VANCE, Hyères, France, were elected to membership.

The Secretary-Treasurer, Mr. ROHWER, read a communication from Prof. E. N. CORY, of College Park, Md., chairman of the Eastern branch of the American Association of Economic Entomologists, announcing a meeting of that organization in New York City beginning on November 21st at 9:30 A.M.

The chair reported the death of Dr. FRANK HURLBUT CHITTENDEN of the Bureau of Entomology on September 15th, 1929, in his 71st year, at his home in Washington, D. C. After a few remarks, by Dr. HOWARD, dealing in a reminiscent way with his associations with the deceased, a committee, consisting of WHITE, QUAINTANCE, and HOWARD, was appointed to recommend. action at the next meeting.

Program: J. M. ALDRICH: *Recent entomological experiences in Europe.* The speaker spent some three months in Europe the past summer. He studied the types of American muscoid flies in the British Museum, and the museums in Stockholm, Copenhagen and Paris. He also collected Diptera in Northern Sweden (Aare and Oestersund) for the purpose of getting material to compare with the northern flies of America, in order to get further information about the species common to the holarctic region. Lantern slides were shown to illustrate the life zones of northern Sweden. (*Author's abstract.*)

Discussed by HOWARD.

F. L. CAMPBELL: *How do insects grow?*

414TH MEETING

The 414th meeting was held November 7, 1929, in Room 43 of the National Museum. The President, Mr. J. E. Graf, presided. Mr. JAMES I. HAMBLETON and Dr. J. W. BULGER, both of the U. S. Bureau of Entomology, were elected to membership.

The following communication was read:

"Your committee recommends that the following paragraph be inserted in the minutes of this meeting:

> " 'The Entomological Society of Washington feels that the death of Dr. FRANK HURLBUT CHITTENDEN has taken from us a devoted and accomplished entomologist whose long term of working years in Washington has enriched entomology in its biologic, taxonomic and economic aspects; that we feel his loss deeply and that we sympathize sincerely with his surviving sister.'

"Your committee further recommends that it be empowered to prepare and publish in the Proceedings of the Society a short account of Doctor Chittenden's life and activities."

Signed: W. H. WHITE
A. L. QUAINTANCE
L. O. HOWARD

Program: R. E. SNODGRASS: *How Insects Fly.*

Insect wings probably were developed from paranotal lobes. The oldest known insects were fully winged—some with flexor apparatus and some without. Wing muscles comprise the dorsal longitudinal muscles, vertical tergo-sternal muscles, pleural muscles, and the flexor muscles. Wing movements of flight consist of up-and-down movements, forward and rearward movements, and partial rotary movements. Up-and-down movements are produced by the dorsal longitudinal and the tergo-sternal muscles, with strong depressor adjuncts in the posterior pleural muscles. Forward, rearward, and rotary movements are produced by the anterior and posterior pleural muscles. Movements by the flexion are produced by the flexor muscles; extension is produced by the anterior and posterior pleural muscles. Flight involves a driving and lifting force; both are produced by the wing movements which create an area of decreased air pressure before and above the insect (DEMOLL). Steering, sidewise and rearward flight, and hovering are functions controlled by the pleural muscles. Organs of equilibrium are not known in insects generally; a few species have organs that are possibly of a static function. (*Author's abstract.*)

Discussed by MCINDOO, CURRIE, MANN, HOWARD, and THONE.

At request of Dr. S. F. BLAKE, Recording Secretary of the Biological Society of Washington, a notice was read by the Recording Secretary of an address to be delivered by Dr. CHARLES WARDELL STILES on *Some Recent Developments in Zoological Nomenclature* at the next regular meeting of that Society to be held at the Cosmos Club on November 16.

Remarks were made on invitation by a visitor, Father O. PIEL, a missionary to China, who was introduced by Doctor HOWARD, and who greeted our Society, expressed his pleasure at being with us, and spoke briefly of his recent travel contacts in this country and abroad.

Mr. ROHWER recorded the recent discovery of the pink bollworm of cotton in the Salt River Valley of Arizona, and the amendment to the quarantine effective on October 31, including within the regulated area Pinal and Maricopa Counties, Arizona. Specimens of this insect were collected in gin trash at two gins on October 24 and forwarded to Washington for final identification. Immediately on this discovery additional scouts were sent to the area and at this time specimens of the pest had been collected in ten different fields and in trash from four different gins. All points where infestations have been discovered are within a comparatively limited area of approximately five miles

southwest of the towns of Mesa and Gilbert. In some fields approximately 85% of the bolls were infested and within the general area in which the larvae had been found the infestation ranged from 5 to 85%.

Mr. ROHWER also referred very briefly to the work done on the Mediterranean fruit fly and stated that no specimens of infested fruit had been discovered at any point within the State of Florida since August 27 nor had any adults been taken in traps since August 14. The apparent absence of fruit fly is very encouraging. During the summer intensive scouting has been done throughout the State of Florida. In addition to the scouting done within this State the States within the cotton belt have been intensively scouted and intensive scouting has also been done in California and the southwestern States. No infestations of the fruit fly have been discovered as the result of this work.

Discussed by WEBB, MCINDOO, and THONE.

415TH MEETING

The 415th meeting of the Entomological Society of Washington was held December 5th, 1929, in Room 43 of the National Museum. The President, Mr. J. E. GRAF presided.

The first item of business was the annual election of officers of the Society for 1930. All of the following were then reelected: *President*, J. E. GRAF; *First Vice President*, A. C. BAKER; *Second Vice President*, F. C. BISHOPP; *Recording Secretary*, J. S. WADE; *Corresponding Secretary-Treasurer*, S. A. ROHWER; *Editor*, W. R. WALTON; *Executive Committee*, the officers and C. T. GREENE, A. N. CAUDELL, and T. E. SNYDER; *Representing the Society as vice president of the Washington Academy of Sciences*, A. G. BÖVING.

Remarks were made on invitation by the following visitors and non-resident members: Dr. C. C. GHOSH, entomologist of the Agricultural College of Mandalay, Burma, India, greeted the Society and spoke appreciatively of his early personal contacts years ago with the officials of our Department of Agriculture and of the aid received from studies of its entomological publications, of his previous associations with Dr. HOWARD, and of his pleasure at opportunity of visiting Washington. He also spoke briefly of the official organization of Agriculture in India and of the character and scope of some of the activities now under way in that country.

Dr. W. V. KING, of the Malaria Mosquito Laboratory at Mound, Louisiana, also addressed the meeting, expressed his pleasure at being with us, and referred briefly to some of his recent work in the Philippines on mosquitoes and flies, specifically, an outbreak of considerable magnitude at Manila last year brought about through an accumulation of decaying algae along a lake shore near the City. He also described in a general way some work of the Philippine Health Service.

Mr. A. F. BURGESS, of the Gypsy and Brown Tail Moth Laboratory at Melrose Highlands, Mass., greeted the Society and referred humorously to some phases of the just completed election of our Society's officers, gave some reminiscences of other meetings attended years ago, and dwelt appreciatively on the work accomplished and the publications issued by our Society.

Program: F. W. POOS: *Leafhopper injury to legumes.* (Illustrated). The study of leafhopper injury to legumes was started in 1928 by the Division of Cereal and Forage Insect Investigations, Bureau of Entomology, in cooperation with the Division of Forage Crops, Bureau of Plant Industry, at Arlington Farm, Virginia, where plantings of the various varieties of forage

crop legumes are maintained by the latter Division and where laboratory and greenhouse facilities are also furnished for these studies. The work has been largely confined to the disease-like injury which is due to some intimate specific relationship other than that of purely mechanical punctures and depletion of plant food and water. About 30 species of leafhoppers, Cicadellidae, occur on forage crops in this section. Twenty of these species have been tested for the disease-like injury to date. *Empoasca fabae* and some of the new species of this genus are the only species in which no individuals have been found that are free from the infectious principle. Occasionally individuals from two other genera of Cicadellidae have been found which apparently caused the disease-like injury similar to that caused by *E. fabae*. The interrelationship of these species, the various responses to their host plants, and the study of their comparative biology makes up a very complicated but interesting field of work.

Observations on the injury and relative susceptibility of various varieties of alfalfa, red clover, sweet clover, white clover, cowpeas, soybeans, peanuts, and potatoes, have been made as well as on many other beans and clovers not mentioned above and on numerous other cultivated and wild hosts. The degree of susceptibility in relation to the amount and type of pubescence is being studied and gives promise of some very interesting results.

The disease-like injury has not been found to be systemic. The infectious principle or toxicity has been found to be inherited through six generations with no apparent loss of virulence. The degree of injury to an individual plant is more or less directly proportional to the number of leafhoppers which are placed upon the plant. If the leafhoppers are removed before the plant is too seriously injured, recovery follows.

Studies on the loss in quality and yield of hay caused by *E. fabae* to alfalfa planted during the spring of 1929 were made in cages one sq. rod in area and covered by tobacco cloth. The hay was carefully harvested, dried, and weighed and then submitted to the Bureau of Agricultural Economics for grading. All the hay taken from infested cages was graded No. 2 whereas all the hay taken from the uninfested cage, both cuttings, was graded No. 1. Based on the weights obtained and the average price for this hay in Kansas City during 1928 and 1929, the loss was 33%.

Preliminary work indicates that control will be largely ecological in that a rearrangement of certain crops may be advisable. A better use of existing varieties and the further development of varieties which best lend themselves to the situation should have due consideration. (*Author's abstract.*)

Discussed by BRIDWELL, GRAF, KING, ROHWER, HOWARD, BALDUF, and EWING.

Notes and exhibition of specimens: Dr. ALDRICH exhibited copies and discussed briefly a number of recently issued scientific and other books, notably: *The Witchery of Wasps*, by RHINEHART; *Instinct and Intelligence*, by KINGSTON; *Handbook of the Dragonflies of North America*, by NEEDHAM and HAYWOOD; *A Manual of External Parasites*, by EWING; *Principles of Systematic Entomology*, by FERRIS; and *An Orphan of Eternity*, by HEINRICH. These remarks were discussed by HOWARD.

J. S. WADE, *Recording Secretary*

PHILOSOPHICAL SOCIETY

997TH MEETING

The 997th meeting was held in the Cosmos Club Auditorium on November 23, 1929.

Program: H. B. BROOKS, *The sensitivity of a galvanometer as a function of its resistance.* Maxwell stated that for the maximum deflection of a galvanometer connected to an external circuit containing a given electromotive force, the galvanometer resistance should bear to the external resistance the ratio, diameter of bare wire (in the galvanometer coil) to its diameter over the insulation. Ayrton and Perry stated that the ratio of these resistances should be unity. Heaviside found that both statements were correct for the respective assumptions, Maxwell having assumed a constant absolute thickness of insulation, Ayrton and Perry a thickness having a constant ratio to the diameter of the bare wire. The Ayrton and Perry theorem has become an established tradition. It appears, for example, in a 1928 textbook on electrical measurements, and in the current catalogue of a prominent instrument maker. An extension of the analysis of the previous writers shows that for each case the curve of relative sensitivity as a function of galvanometer-coil resistance has such an extremely flat maximum that one may largely depart from the traditional optimum condition with only small loss in sensitivity, and with a considerable gain in most cases because considerations of proper damping forbid the use of modern moving-coil galvanometers on an external circuit of resistance equal to that of the coil. Because of the extreme flatness of the maxima, galvanometer makers need to construct, and users need to purchase, galvanometers of relatively few values of coil resistance, in order acceptably to cover all but very unusual requirements. (*Author's Abstract.*)

HOWARD S. RAPPLEYE, *Observers' patterns.* This paper constitutes a brief review of the material presented about a year and a half ago on Observers' Patterns, or the personal equations of observers engaged in the first-order leveling of the U. S. Coast and Geodetic Survey. In addition to the review of the first paper additional data were presented on the progress of the investigation since the first presentation. A piece of test apparatus was shown which was designed with the idea of compressing a "pattern test" into a sample of 100 separate estimations by having them distributed uniformly throughout the range of observations but presented to the observer in a random order. In its present form this apparatus, while it provided some useful sidelights on the whole matter, failed to provide a proper test. Additional work with it may possibly reveal the cause of the failure and make it, when properly modified, a useful adjunct to the test apparatus and program. A "1,000 test" in which the readings are taken at random on four separate positions of rod and instrument but the readings in each group being scattered up and down the rod in an accidental manner, was reported upon and a sample tally sheet shown. It was noted that the groups of 250 observations in each position exhibited the same general characteristics, which seems to further substantiate the belief that a sample of 1,000 to 1,500 observations taken at random is a large enough sample to bring out a characteristic pattern for an observer. A series of patterns were shown illustrating the behavior of an observer throughout a series of tests when the results of each preceding test were known to him. Also patterns were shown illustrating the behavior of the same observer after he had taken the field on actual leveling.

Another series of patterns illustrated the "shaking down" process of a new observer by exhibiting a gradual change in his pattern throughout the first half of a field season and a practically constant pattern or personal equation during the last half of the season. (*Author's Abstract.*)

OSCAR S. ADAMS, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

According to the *Journal of Agricultural Research* the tobacco plant shows specific symptoms of a deficiency of magnesium and of calcium in some light-sandy and sandy-loam soils. Fertilizers for such soils should contain small quantities of calcium and magnesium; 180 pounds of magnesium sulphate per acre in the drill or 500 to 1000 pounds of dolomitic limestone broadcast will effectively prevent symptoms of magnesium deficiency.

JOHN C. REED, recently appointed Senior Scientific Aid on the Geological Survey, is at present assisting the Chemical Laboratory in the determination of mineral specimens. In addition to such determinations made in the course of its regular work, the Survey identifies over 2000 specimens a year for the public.

L. W. STEPHENSON has resumed his duties as Chief of the Section of Coastal Plain Investigations in the Geological Survey after a four-months furlough for field work in Venezuela.

Miss JULIA GARDNER, who has spent the winter in examining collections of Tertiary and Cretaceous fossils in foreign museums and in visiting outcrops of fossiliferous strata in England and Denmark, returned to Washington early in March.

Dr. N. ERNEST DORSEY, having completed his work as associate editor of the International Critical Tables, has returned to the Bureau of Standards.

Mrs. AGNES CHASE, Associate Botanist in the Grass Herbarium, writes from Brazil that she had a severe trip ascending the mountain peak Caparaó in company with a botanical companion, Mrs. MEXIA. She was assured "it would be impossible for the senhora to climb Caparaó," but after much insistence arrangements were made. Rain fell most of the time and everything was soaked. The first night out was to be spent at a cave which was reached about 4:30 P.M. It looked very inviting at first as it was dry, but the guide commented on the pulgas (fleas). She and her companion finally made camp in the rain rather than endure the fleas. They had dry clothes for the night but got back into wet clothes at day break. The trail became very steep through the bamboo zone. At last about 3:30 they struggled out of the bamboo into the campo. Antonio (the guide) said something about 'muita corajosa' [very courageous] for senhoras to make that ascent. He said no woman had ever done it before and very few men. Mrs. CHASE at Viçosa visited Professor ROLFS, who is an American in charge of a large and important agricultural school. Traveling alone, she collected at Hargreaves and Bello Horizonte.

Mr. MATTHEW W. STIRLING, Chief of the Bureau of Ethnology left Washington January 13 for a cruise among the Ten Thousand Islands between Charlotte Harbor and Cape Sable, Florida, where he hopes to discover evidences of

the former occupancy of this area by the Caloosa Indians. He will be aided by Mr. LEE PARISH, of Tulsa, Okla., whose 85-foot yacht, *Esperanza*, will furnish transportation. After his explorations in the Ten Thousand Islands region Mr. STIRLING will excavate a large sand mound on the west Coast of Florida, located south of Tampa Bay.

Obituary

Capt. JAMES PERCY AULT, who was killed on November 29, 1929, when an explosion destroyed the non-magnetic ship *Carnegie* in the harbor of Apia, Western Samoa, was born on October 29, 1881, at Olathe, Kansas, and educated at Baker University where he received an A.B. degree in 1904. Even while studying in the University he took an active interest in the work of the then newly established magnetic observatory of the United States Coast and Geodetic Survey at Baldwin, Kansas, where he served as observatory assistant from January 1901 to June 1904. In the latter month he was appointed as magnetic observer in the Department of Terrestrial Magnetism of the Carnegie Institution, and the next year, after receiving the necessary preliminary training on the U. S. Coast Survey vessel *Bache* on a cruise from Baltimore to Panama, he was assigned to scientific work on the magnetic-survey vessel *Galilee* where he remained until November 1906. During the next two years he was engaged at the office of the Department in Washington and on magnetic field work in Mexico and Canada, carrying out in the latter country a difficult exploratory trip in the course of which he secured magnetic results in territory where none had previously been obtained. In order to fit himself more thoroughly for a scientific career he next pursued postgraduate studies at Columbia University from which institution he received an A.M. degree in 1909. In view of his skill and experience gained on earlier expeditions, he was again, in 1912, placed in charge of field parties in Peru, Bolivia, and Chile, for the purpose of training new observers in making magnetic determinations under field conditions.

In the general plan of a magnetic survey of the Globe which constituted one of the major operations of the Department, the ocean work of the non-magnetic ship *Carnegie* was destined to play an important part. For the successful execution of this ambitious undertaking, Captain Ault, first as a member of the scientific staff under its first commander William J. Peters, and later as commander of the vessel, has been largely responsible.